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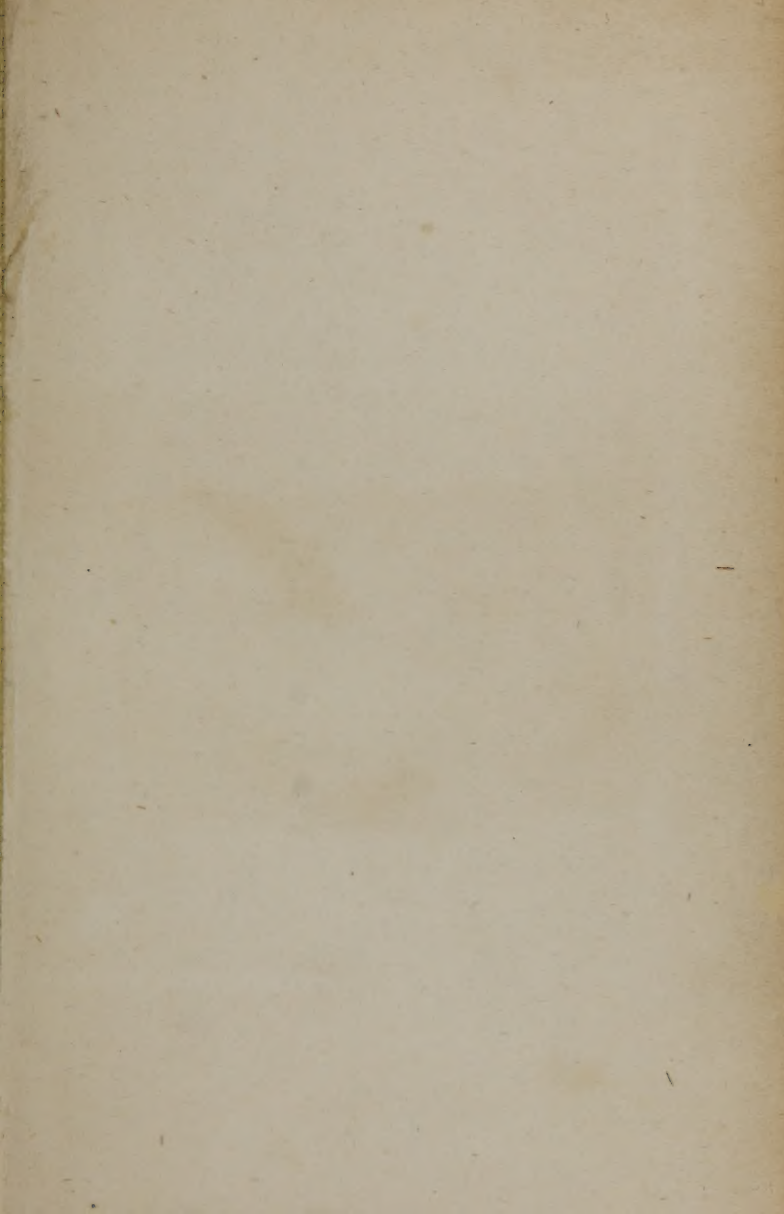
Medical Chemistry

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DOCTOR F. H. BOKER

MEDICAL CHEMISTRY

LECTURES BY F. H. BOKER, M.D.

OF THE UNIVERSITY OF CHICAGO

CHICAGO, ILL.

1900

THE UNIVERSITY OF CHICAGO PRESS

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DOCTOR F. W. BÖCKER'S

MEDICAL CHEMISTRY,

FOR

PHYSICIANS AND STUDENTS OF MEDICINE,

OR

PRACTICAL INSTRUCTIONS IN

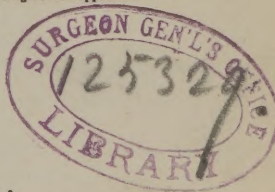
ZOO-CHEMICAL ANALYSIS.

TRANSLATED AND ARRANGED BY

A. ZUMBROCK, M. D.

With 24 Engravings.

Accompanied by a box containing all the necessary reagents and apparatus.



PHILADELPHIA:

F. E. BERICKE.

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Annex

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EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Uric acid*, differently formed, partly by solution and crystallization of chemically pure uric acid, partly by the actions of acids on sediments of urates, and partly by spontaneous decomposition of urine.
- Fig. 2. *Uric acid*, in different other forms.
- Fig. 3. Sediment of urine, consisting of *uric acid*.
- Fig. 4. Crystals of *uric acid*.
- Fig. 5. Crystals of *hippuric acid*, from normal human urine; in the lower part of the left side of the figure there are crystals of hippuric acid, which are formed by very slow decomposition, they are precisely like tribasic phosphate.
- Fig. 6. *Urea* of human urine.

PLATE II.

- Fig. 7. *Nitrate of urea*.
- Fig. 8. *Oxalate of urea*.
- Fig. 9. Crystals of *Kreatinine*.
- Fig. 10. 1. Air-bubbles.—2. Fat.—3. Globules of blood.—4. Spermatozoa.—5. Epithelium.—6. Mucus.
- Fig. 11. Crystals of *Kreatine*.
- Fig. 12. *Urate of soda*, artificially made.

PLATE III.

Fig. 13. Urinary sediment of *urate of soda*. The common whitish, yellow, or brick-colored sediment, which is deposited on cooling by acid urine—particularly in fevers—consists nearly exclusively of urate of soda.

Fig. 14. *Urate of ammonia*.

Fig. 15. *Tribasic phosphate of lime*.

Fig. 16. Sediment of *tribasic phosphates* and numerous granules of mucus, which was deposited from the fresh, alkaline, turbid urine of a patient, suffering with catarrh of the bladder. The crystals of the double salt of phosphate of ammonia and magnesia show different forms. The mucus is in small, strongly contracted granules.

Fig. 17. Sediment of *tribasic phosphate* and *urate of ammonia*, from urine, which was completely decomposed by very long standing exposed to the air. The large, fine crystals are phosphate of ammonia and magnesia.

Fig. 18. *Bi-basic phosphate of lime*.

PLATE IV.

Fig. 19. *Oxalate of lime*.

Fig. 20. *Cystine*.

Fig. 21. *Cholesterine*.

Fig. 22. *Cholesterine*.

Fig. 23. *Taurine*.

Fig. 24. *Butyric acid*, deposited under the microscope from a hot solution.

INTRODUCTION.

§ 1.

The benefit which practical medicine has derived from the progress in Chemistry is immense, and a fact admitted by all, still every practising physician knows, that so far, Chemistry with all its analyses, has done but little to help him in curing his patients. The reason of this lies partly in the professional chemists not knowing the wants of practical physicians, and their being too little acquainted with Therapeutics, and partly in the physicians themselves, possessing too little knowledge of practical chemistry, so as to enable them to perform the necessary analysis. It is generally believed, that in order to make a chemical analysis, a great amount of study and practical training in laboratories is required. This may be true with regard to very accurate and complete analyses, still it is none the less true that every man of ordinary capacity, may, with due care and a few patient experiments, become in a short time sufficiently competent to solve all the chemical problems which are treated of in this little work. The numbers of analyses is sufficiently large to enable any physician who knows how to perform them, to answer many important questions in Physiology, Pathology, Pharmacology and Therapeutics.

As *quantitative* analyses require more time, skill and apparatus, than are at the disposal of most medical practitioners and students, there are, with a few exceptions, almost exclu-

sively *qualitative* analyses given in this work. Another reason for confining ourselves to *qualitative* analyses, was the desire of fixing the price of the book and box, which contains all the reagents and apparatus, called for in this book, at so low a price, as to place them within the reach of every practitioner and student.

One accurate pair of scales alone—indispensable in quantitative analyses—costs nearly twice as much as this book and box together.

2. Reagents and Apparatus contained in the accompanying box.

Acetic acid.

Nitric acid.

Hydrochloric acid.

Oxalic acid, in a dry state, as the solutions of it soon spoil; for use it is to be dissolved in alcohol or water.

Tartaric acid, dry; to be dissolved in water.

Chloride of barium.

Nitrate of silver.

Chloride of ammonium, dry; to be dissolved in 8 parts of water.

Chloride of platinum.

Phosphate of soda, dry; to be dissolved in 10 parts of water.

Oxalate of ammonia.

Ferrid-cyanide of potassium.

Sulphate of copper, to be dissolved in water.

Sulphate of lime.

Caustic potash.

Antimoniate of potassa.

Metallic zinc.

Litmus-paper, blue and red.

Quick-lime and Lime-water are not in the box, they are too easily decomposed, and may be had everywhere. Water in this book, means distilled water, in most cases pure rain-water may be used.

Apparatus contained in the box.

1 Spirit-lamp, of glass.*

1 Piece of platinum-foil.

$\frac{1}{2}$ doz. test-tubes.

2 Porcelain crucibles.

2 Porcelain evaporating dishes.

2 Watch crystals.

2 Glass funnels.

Several glass-rods.

Several bent glass-tubes, for disengaging gas.

1 Pair of pincers.

1 Blow-pipe.

1 Magnifying glass, (3 glasses.)†

This magnifier will, in most cases, be found sufficient to recognise the forms of crystals, as represented on the plates, for which purpose in the text the microscope is mentioned.

Before using a reagent, we should always well consider what we apply it for, what we expect to see. A very common fault is to use too much of the reagent; in most cases a few drops only are necessary. In some cases a good method of applying the reagent is to pour a few drops of the fluid to be tested, upon a watch-crystal, and to apply the reagent by means of a clean glass-rod, which had been dipped into the reagent.

When boiling in a test-tube, the tube with the fluid should be gradually heated by turning and moving it constantly, and particular care should be taken not to touch the wick with the tube, as that would crack it. The tube must be held obliquely over the lamp. To protect the fingers against the heat of the hot tube, pass a long, narrow piece of paper around the top of the tube, and take hold of the two ends of the paper.

The large sized tubes may be used instead of flasks.

* A very good Berzelius' spirit-lamp may be had from the publisher for about \$5 00.

† Microscopes may be procured from the publisher at the following rates: French ones from \$2 50 to \$10 00—power, 45 to 200 diameters. Achromatic microscopes, English and others, from \$25 00 to \$100 00—power up to 800 diameters.

§ 3.—Chemical Operations.

1. *Dissolving, Extracting, Digesting, Exhausting.*

A substance can be more easily *dissolved* the more finely it is divided or pulverized. Some animal substances can be better pulverized when warm, some when cold. Soft parts, as flesh, tumors, cellular tissue, must be triturated in a mortar. Water, alcohol, ether, acids and alkalies, are used as solvents for organic substances. When alcohol or ether are used, it is advisable to heat in a water-bath.

Most substances we analyze are mixtures of different substances, of which a certain solvent takes up one or more, this partial dissolving is called *extracting*. Extracting by means of heat (of a water or sand bath,) is called *digesting*.

Exhausting a substance, means to extract it so long with fresh portions of a solvent, as the last fresh portion of the latter does not dissolve any more; this may be ascertained by evaporating a drop of the last portion of the solvent on platinum foil, if it leave no residue whatever, the substance is exhausted.

2. *Crystallization, Precipitation, Filtration, Decantation.*

Certain organic substances form *crystals*, under certain circumstances; to obtain them as pure as possible, a solvent is used, which dissolves only the substance wanted in the crystalline form. Sometimes other matter is taken up in solution, which stains the crystals, or prevents, or retards, their formation; in these cases the solution should be boiled with animal charcoal, filtered and evaporated. Crystallization is sometimes promoted by ice or snow, as in the case of nitrate of urea. Substances which do not crystallize are called *amorphous*.

Precipitation is used to separate a dissolved substance from the dissolving fluid by means of proper reagents, the newly formed or separated substance being insoluble in the fluid.

When the precipitate is so finely divided, and when there is so little of it, that its particles cannot be distinctly perceived,

the fluid containing this suspended precipitation is said to be *turbid*. Precipitation is promoted by violent shaking and heating the fluid. The most convenient vessels to precipitate in are test-tubes.

Filtration is used to separate an undissolved substance, as a precipitate, from a fluid. Filtering is done by means of a glass funnel and filtering-paper, the filter. The paper is cut in a circular form, folded in the shape of a quadrant, the pointed part put deep in the funnel, and one of the folds spread back so that the paper completely lines the glass, though it must not quite reach the top. When the paper is nearly fitted, it is moistened by a jet of water, to cause it to adhere to the glass. This moistening with water should not be done if the undissolved substance to be separated is soluble in water. Should the fluid running first through the filter, be turbid, it must be returned upon the filter until it runs quite clear. Some pieces of glass-rod put between the filter and the funnel, favor the filtration much.

Decanting is used to separate a fluid from a deposit, it is often used in combination with filtering, the clear supernatant fluid is first decanted, and then the turbid portion filtered. To avoid the possibility of any of the liquid running down the outside of the vessel, some tallow should be smeared along the outside of that part of it over which we wish to pour the fluid.

3. *Evaporating and Drying.*

Evaporating is done in vessels of porcelain or glass, in a sand, water, or oil-bath. A sand-bath is easily made by filling an iron pot with sand, heating it, and placing the vessel containing the fluid, upon the hot sand. A water-bath consists of a metallic vessel with a ring or cover with one or more openings, in which the porcelain dish or other vessel is placed; the metallic vessel is filled to about two-thirds with water, and kept boiling. In this bath the temperature can never rise above 212°. If a higher temperature should be necessary, oil must be substituted for water. For evaporating small quantities, watch crystals are very convenient.

Evaporation is much promoted by stirring the fluid; and drying by finely dividing and spreading out of the substance.

4. *Incineration*

Is employed to obtain mineral substances free from organic matter. The substance to be incinerated must be first dried, then exposed in a porcelain crucible, or on platinum, to the heat of a spirit-lamp. Should this heat be insufficient to completely incinerate the coal, blow very gently upon the coal with the blow-pipe, and if this does not answer the purpose, add a few drops of nitric acid, or what is still better, a little nitrate of ammonia, the ammonia is at once volatilized, and the oxygen of the nitric acid oxydises the carbon. When carbonates are present, nitric acid and nitrate of ammonia must not be employed, they decompose the carbonate.

If not only the incombustible salts, but all salts of an animal substance, for instance, of the blood, are to be determined, the substance is first only charred at a moderate heat, the charred mass exhausted with water, hydrochloric acid &c., and then completely incinerated.

A little at a time ought to be put into the crucible, as some organic substances, as the residue of urine, swell much, and sputter when strongly heated.

5. *Neutralizing*

An alkaline or acid fluid, means to add to the first acid and to the second alkali, in such a quantity that the fluids act now neither on the blue nor on the red litmus-paper. We call adding an acid or alkali in excess, when we add to an alkaline fluid so much acid that it turns blue litmus-paper red, and when we add to an acid fluid so much alkali, that it turns red litmus-paper blue. Before testing in these cases with litmus-paper, the fluids should be well shaken, and it should be recollected that carbonic acid gas turns blue litmus-paper temporarily red.

§ 4. Preliminary Examinations.

It may here be remarked, that when analysing any substance, every thing relating to it and every result of a test, positive as well as negative, should be put down in writing; what seem at first to be mere trifles, may be of the utmost importance afterwards.

If an animal substance is to be analysed, examine its physical properties as color, odor, appearance, &c.

Test its reaction on litmus-paper, if it be a solid substance dissolve it first in distilled water, or any other neutral fluid.

The specific gravity may be sometimes of importance, but that the knowledge of the specific gravity of urine is of no value whatever, in determining the proportion of its solids, will be shown under urine.

§ 5. Examination of a Substance for Organic Matter.

To ascertain whether a substance be organic or inorganic, place a little of it upon a piece of platinum foil—a cork slit and slipped on one end acts as a handle—and heat slowly over a spirit-lamp, carefully observing any appearance of vapor or smoke, charring, and partial or complete combustion. If it now turn black, and if this black color be not soluble in acids and alkalies, the presence of an organic substance is certain. The non-appearance of the black color does not prove the absence of an organic substance; the black color will sometimes appear when heated with an incombustible substance, as sulphate of soda. There are organic substances which contain no carbon, and do therefore not char. To complete the test, the heat may be increased by means of the blowpipe, by blowing the flame against the underside of the platinum foil, below the substance to be tested. Any residue upon the platinum foil now, shows the presence of *mineral substances*; some inorganic substances are volatile as compounds of ammonia, chloride of sodium. The gradual disappearance of a volatile metal must not be con-

founded with the phenomena characteristic of an organic substance undergoing combustion.

§ 6.—Test for Nitrogen, Sulphur and Phosphorus.

To test a substance for any of the above substances, all salts containing nitrogen, sulphuric or phosphoric acid, must first have been removed. This is done by exhausting the substance first with boiling water, and then with water containing hydrochloric acid; proceed then as follows:

1. *Nitrogen*.—Burn the substance, if it contain much nitrogen, it will evolve the peculiar odor of burned hair; mix the pulverized substance with soda and quick-lime, put the mixture in a test-tube, closed with a well fitting cork, through which one end of a bent glass tube passes, dip the other end of the glass tube in a vessel containing absolute alcohol and a few drops of hydrochloric acid. Now heat the mixture in the test-tube. The evolved gas passes through the alcohol. Add to this alcohol a few drops of chloride of platinum, if this produce a yellow precipitate, nitrogen is present. The nitrogen present in the substance, when heated with soda and lime, forms ammonia, this passes over, combines with the hydrochloric acid, forming chloride of ammonium, which is precipitated by the reagent.

2. *Sulphur*.—If the substance be dry, mix it with pure soda and nitre, melt a little nitre in a porcelain crucible, and add the mixture by degrees. If sulphur be present, a part of the oxygen of the nitric acid oxydizes the sulphur to sulphuric acid, which combines with the potassa of the decomposed nitre. Dissolve the mass in water, add a few drops of hydrochloric acid, and then add chloride of barium, which will produce a white, heavy precipitate of sulphate of baryta. If the substance be fluid, add hydrochloric acid and test for sulphuric acid by the chloride of barium.

3. *Phosphorus*.—Mix with soda and nitre, and melt as in the case of sulphur, dissolve the melted mass in distilled water, add an excess of ammonia, then add chloride of ammonium and

sulphate of magnesia. If phosphorus were present, phosphoric acid was formed, which produces, with ammonia and magnesia, a white precipitate of the double salt of phosphate of ammonia and magnesia.

According to Will, "very small quantities of *free* phosphorus (as in poisoning by this substance), mixed with organic matters, can be most certainly indicated if the pap-like substances be mixed with water and some hydrochloric acid, in a porcelain bowl, then warmed, being constantly stirred, up to the melting point of phosphorus, and after the mixture has settled, the supernatant liquid is poured off in perfect darkness. The smallest pieces of phosphorus can be recognized by their luminosity."

§ 7. A. Urine.—Normal Urine.

Physical Properties and Composition.

Fresh, *normal* urine, is a clear wine or straw colored fluid, of a bitter, salty taste, and distinctly acid reaction. Its specific gravity varies from 1.004 to 1.030. On cooling, it frequently forms sediments of different colors. After some time it becomes paler, forms a sediment of mucus and epithelium, smells of ammonia, shows alkaline reaction; a whitish film covers the surface, and soon whitish, cloudy masses appear at the bottom of the vessel, in which even the naked eye can perceive crystals of the double salt of phosphate of ammonia and magnesia. In putrid urine, the urea is transformed into carbonate of ammonia, it therefore effervesces with an acid.

Composition of Normal Urine.

Water,	Coloring and extractive matter.
Urea.	Carbonic acid, free or combined with a base.
Mucus.	
Kreatine,	
Kreatinine.	

Chlorine,	}	<i>combined with a base.</i>	Ammonia,	}	<i>combined with an acid.</i>
Uric acid,			Kalium,		
Hippuric acid,			Sodium,		
Phosphoric acid,			Calcium,		
Sul huric acid,			Magnesium,		
Silicium as silica,			Iron,		

How these substances are combined in normal urine, will be explained hereafter, but it may here be remarked, that the different salts are not separated as such from the urine, the acids and bases only are ascertained by analysis, from which the salts are calculated according to their known chemical affinities.

§ 8. Analysis of Normal Urine.

It has been stated before, that this little work would contain only qualitative analyses, yet in the case of urine, and more particularly in that of milk, it has been deemed proper to deviate from this rule, partly because these analyses can be made with little trouble, and partly because of their great importance.

To arrive at useful and true results, the urine of a certain time, as twenty-four hours, ought to be carefully collected, and kept in a cool place, at a temperature below 41° F., a precipitate of uric acid, and urate of soda or ammonia often appears, which however, disappear when the urine is gently heated. At a temperature above 60° F., a sediment of earthy phosphates is formed, which may be dissolved in a few drops of nitric acid, when it is to be tested for urea and uric acids. In analyses for inorganic substances, this sediment is of no consequence. We make a note of the color of the collected urine, its smell, reaction on litmus-paper, whether it be clear or turbid, and of its specific gravity. The specific gravity of urine, even not considering the great difficulty of ascertaining it accurately, all areometers for this purpose being not accurate enough, is scarcely of any use in determining the proportion of the solids. As a proof of this assertion, I quote from the writings of three of the

best authorities in those matters. The per centage of salts in urine of a certain specific gravity is stated by

A. Becquerel.	F. Simon.	Golding Bird.
1.650 per cent.	1.927 per cent.	2.327 per cent.
For urine of 1.010 specific gravity.		
3.300 per cent.	4.109 per cent.	4.659 per cent.
Specific gravity, 1.020.		

§ 9. Water, Solids, and Incombustible Salts.

The collected urine is to be carefully weighed, the whole well mixed by shaking or stirring, and a small quantity, say one-half an ounce weighed and evaporated to dryness in a small porcelain crucible of known weight. The weight of the crucible subtracted from the weight of the crucible and its perfectly dry contents, gives the weight of *solids* in one-half an ounce of urine; the loss is *water*. The proportion of solids and fluids in 100 or 1000 parts, may then be ascertained by simple calculation. To ascertain the amount of incombustible salts, heat the crucible and its dry contents until all organic substances are burnt, and the residue will appear perfectly white, weigh again, and calculate as above. In calcining these salts, there will be a small loss of not more than one in a thousand parts. If urine containing albumen or sugar is to be burned, a deep crucible, and not too much urine should be used, these substances swell very much when burned.

§ 10. Sulphuric Acid



Is contained in urine, as a sulphate, particularly as sulphate of potash.

1. The presence of sulphuric acid, free or in its soluble salts, is shown by a white precipitate, which is caused by a soluble salt of baryta, as chloride of barium, in acid and neutral solu-

tions, well diluted with water. This precipitate of sulphate of baryta is insoluble in hydrochloric and nitric acids.

2. Acetate of lead precipitates sulphate of lead, a heavy, white precipitate, with difficulty soluble in dilute nitric acid, but completely soluble in hot concentrated hydrochloric acid.

3. Nearly all the sulphates are soluble in water, but insoluble in alcohol and ether, both of which take up sulphuric acid. This gives us a method of detecting free sulphuric acid in urine or other fluids, viz., fresh urine should be shaken with sulphuric ether, the ether decanted from the urine upon a watch-crystal, and evaporated, a little distilled water and a drop of hydrochloric acid added, and then tested with chloride of barium, but if the acid is to be detected in the solids of the urine, they should be dried, extracted with absolute alcohol, and then tested as above.

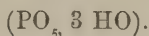
§ 11. Chlorine

(Cl).

Is found in urine, in combination with sodium and potassium, and perhaps also with ammonium.

The best test for the combinations of chlorine, is nitrate of silver, it forms with it a whitish precipitate, like curds of milk, which turns violet on the surface when exposed to the light. It is insoluble in nitric and other acids, but soluble in ammonia. If a fluid contains only traces of hydrochloric acid, the nitrate of silver forms no precipitate, but the fluid becomes opalescent, and milky white. When this test is to be applied to urine it must first be diluted with one-third its weight of distilled water, and a little nitric acid. To detect free hydrochloric acid in urine, shake it with ether, decant, evaporate, add water, and then test with nitrate of silver.

‡ 12. Phosphoric Acid.



In urine, and in fact in the whole human organism, the common or tribasic phosphoric acid only is found, it is combined with potash, soda, lime, magnesia, and perhaps iron.

1. Chloride of barium produces in watery solutions of neutral and basic phosphates, a white precipitate of phosphate of baryta, soluble in hydrochloric and nitric acids, but soluble with difficulty in chloride of ammonium

2. A solution of sulphate of lime, gypsum, produces in neutral or alkaline solutions, a white precipitate of phosphate of lime, freely soluble in acids, even in acetic acid.

3. Nitrate of silver produces in solutions of neutral or basic phosphates, a precipitate of yellow phosphate of silver, soluble in nitric acid and ammonia.

4. When to fresh urine ammonia is added in excess, all phosphates of lime and magnesia will be precipitated, let it stand for twelve to twenty-four hours, filter, add to the filtered fluid a concentrated solution of salammoniacum, and then sulphate of magnesia, which will precipitate all phosphates of potash and soda.

To test urine for free phosphoric acid, shake it well with ether, dilute the decanted ether with water, evaporate and test the residue for phosphoric acid.

‡ 13. Carbonic Acid



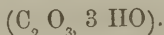
Occurs in urine, either free or in combination with a base.

1. Solutions of quick-lime, or caustic baryta produce with carbonic acid, or a soluble carbonate, white precipitates of neutral carbonates of lime or baryta, soluble in acids with effervescence.

2. The carbonates are decomposed by all the acids, except hydrocyanic and hydro-sulphuric acid, the carbonic acid passes off as a colorless, and nearly inodorous gas, which reddens litmus-paper *temporarily*. To prove that the escaping gas is carbonic acid, let the gas pass through a glass tube into lime-water, when this becomes turbid, the gas is carbonic acid.

3. Chloride of calcium and chloride of barium, produce in neutral carbonates at once, in bicarbonates only when boiled, white precipitates.

§ 14. Oxalic Acid



Is found in urine combined with lime and other substances.

1. Oxalic acid forms oblique, rhombic, generally striated, incompletely developed prisms, rarely rhombic octahedrons, of very sour taste, and of no color.

2. The dry acid is sublimed by heat, and condenses unchanged. Substances which part easily with their oxygen, as nitric acid, oxide of silver, &c., convert oxalic acid into carbonic acid.

3. Chloride of barium produces in neutral oxalates, a white precipitate, soluble in nitric acid.

4. Nitrate of silver forms in neutral solutions, a white precipitate of oxalate of silver, soluble in nitric acid and ammonia.

5. Lime-water, and all soluble salts of lime, produce in solutions of free and combined oxalic acid, even if very much diluted, a fine, white, heavy precipitate of oxalate of lime, easily soluble in nitric and hydrochloric acids, but insoluble in acetic acid. This precipitation is favored by ammonia, but prevented by ammoniates.

6. To find oxalic acid in any animal substance, extract it with diluted hydrochloric acid, add ammonia in excess, and then acetic acid, until its reaction is quite acid. Should oxalic

acid and lime have been present together, ammonia will have produced a precipitate, which on the addition of acetic acid, did not disappear entirely. But should oxalic acid, without the presence of lime be suspected, which, until now has never been observed in animal substances, some chloride of calcium must be added to the solution acidulated with acetic acid, a precipitate then proves the presence of oxalic acid.

§ 15. Uric Acid



Is in urine generally combined with soda, potash, or ammonia, free only when precipitated by an excess of acid.

1. It forms white, light, soft crystals, (see plate I., fig. 1, 2, 3, 4,) is tasteless and inodorous, soluble in 11,000 to 15,000 parts of cold, and in 1,800 to 1,900 parts of boiling water, scarcely soluble in hydrochloric acid, totally insoluble in alcohol and ether. Concentrated sulphuric acid dissolves it at once, cold water precipitates it from this solution. It is easily soluble in the carbonates, phosphates, lactates and acetates of the alkalies, forming urates with the alkalies. A hot solution of uric acid and moist uric acid, reddens litmus-paper. Uric acid is very readily decomposed at a temperature of only 60° to 70° F., most probably converted into ammoniacal combinations. Urine which has been decomposed by long keeping, contains no longer any uric acid.

2. Concentrated nitric acid decomposes and dissolves uric acid, changing the color to yellow; carbonic acid and nitrogen escape. If this solution be evaporated to dryness, a reddish mass remains, which when moistened with a trace of ammonia, turns beautifully scarlet. Moistened with caustic alkali, it becomes beautifully violet.

3. The process of detecting uric acid depends on the nature of the fluid in which it is supposed to be present.

a. In the *sediment of urine*.

By means of the microscope.

β. Chemically. Boil the urine with the sediment, filter hot, all the water, and some uric acid pass through the filter. Wash the substance remaining on the filter well with cold water, and dry; mix a part of it in a small porcelain dish or watch-crystal, with moderately diluted nitric acid, and heat gently. If the crystals are really uric acid, they are dissolved; evaporate the yellow fluid almost to dryness, and bring near the residue a glass rod moistened with ammonia. If uric acid be present, it will turn beautifully scarlet, which color will also appear if the evaporation of the yellow fluid be continued to dryness. Let it become cold, and add some fluid caustic potash, it will now turn deep blue or purple. Every excess of ammonia is carefully to be avoided, for if there are only traces of uric acid, the reaction cannot be seen. It is best to hold the glass rod moistened with ammonia, near the residue, and blow the ammoniacal vapor upon it.

b. In *urine*; mix urine with one-tenth of pure hydrochloric acid, stir well and let it stand for twenty-four to thirty-six hours. All uric acid, which has been separated from its combinations with soda and potash by the hydrochloric acid, will have been precipitated. It can be tested as above.

c. In *blood* and *fluids* containing *albumen* and *caseine*. Uric acid in the blood can best be shown in the serum, it is there combined with a base. Evaporate the serum to dryness, extract with alcohol, and boil the residue with water, concentrate the watery extract by careful evaporation, removing from time to time the film which forms on the surface, add acetic acid to excess. If uric acid be present, it will now be separated, and may be proved to be such chemically, or by means of the microscope.

d. Is a *solid animal substance* to be tested for uric acid, and the fluid existing in it be of alkaline reaction, boil the well divided substance for a few minutes with water, evaporate the filtered fluid, add acetic acid, and make the above test.

e. If the fluid existing in the solid animal substance be acid, add enough of a very much diluted solution of caustic potash, to make it alkaline, boil, filter hot, evaporate, add acetic acid, and so on.

§ 16. Hippuric Acid



Is found in the urine of several graminivorous animals as the horse and camel. It is sometimes found in human urine in the same quantities as uric acid. It is present in large quantities in the urine of persons who have taken benzoic acid; but it was never found in the urine of persons who had been fasting for eighteen or twenty-four hours before voiding the urine. It cannot be considered as a constant constituent of the normal human urine.

1. Hippuric acid crystallizes in beautiful, long, rhombic prisms; from cold solutions it separates in long needles, see plate I., fig. 5. Although it has no acid taste, it reddens litmus-paper; it melts at a moderate heat, and forms on cooling a crystallized mass. If kept for some time at a temperature of 390° F., some traces of benzoic acid are sublimed, the mass turns red-brown, remaining on cooling transparent, without becoming crystallized; but if it be dissolved in boiling water, it crystallizes on cooling in long needles. At the usual temperature, hippuric acid is soluble in 400 parts of water; boiling water and alcohol dissolve it easily; cold and boiling ether dissolve it sparingly. At 240° F. sulphuric acid dissolves it without blackening or charring; at a higher temperature, benzoic acid is formed. From a hot solution in hydrochloric acid, it crystallizes on cooling unchanged; boiling nitric acid dissolves it, but the solution then contains benzoic acid. By boiling it for a long time in hydrochloric, dilute sulphuric or oxalic acids, it is decomposed into benzoic acid and gelatine sugar, which enters into combination with the acid applied. Diluted solutions of hydrate of soda or potash decompose it. When subjected to dry distillation, benzoic acid and benzoate of ammonia are sublimed, while at the same time an oily fluid passes over, which on cooling becomes solid, is insoluble in water, but soluble in alcohol and ether, and resembles resin. Exposed

to a still higher temperature hydrocyanic acid passes off, and a porous coal remains.

2. To detect hippuric acid in any animal substance evaporate the clear fluid, or the filtered aqueous extract of the substance (if acid, neutralize with lime-water), to a syrup, and add hydrochloric acid. If now acid crystals are not deposited, which are easily soluble, and which, when crystallized again, form long needles, indicating a large quantity of the acid, shake the residue with ether. Decant the ether, and leave it to spontaneous evaporation, when long needles of hippuric acid will be deposited. If the ether cannot well be separated from the thick fluid, add one-twentieth its volume of alcohol, shake well, and separate the ether, wash the ether repeatedly with water, and let it stand in a moderately warm place, when long, acid, needle-like crystals are deposited, showing undoubtedly the presence of hippuric acid. To be sure of their difference from crystals of benzoic acid, heat them in a test-tube to about 270° F., hippuric acid will remain unchanged, while benzoic acid will be completely sublimed.

§ 17. Ammonia.

(N H_3).

It is yet a disputed fact, whether salts of ammonia be present in fresh, normal urine. It seems that fresh urine of healthy persons contains sometimes ammoniacal salts, and often not. In what combinations it occurs in fresh normal urine is not known.

1. All salts of ammonia are volatile at a moderate heat, they are volatilized either unchanged or decomposed. Most of them are soluble in water; the solutions colorless. The neutral compounds of ammonia and a strong acid do not change vegetable colors.

2. When triturated with caustic potash or lime, with a few drops of water, ammonia is evolved, easily recognised by its well known odor, by its action on moist red litmus-paper,

which it makes blue, and by the formation of white vapors, when approached by a glass rod, moistened with hydrochloric, nitric, or acetic acids. Hydrochloric acid is a very delicate, but acetic acid a surer test.

3. Chloride of platinum produces in neutral and acid solutions of salts of ammonia a yellow, crystalline precipitate; alcohol favors this precipitation much.

To detect salts of ammonia in much diluted solutions which contain substances, as urea, that are transformed by heat into compounds of ammonia, add to the solution two parts of a mixture of absolute alcohol and ether, and then chloride of platinum. Or if the solution may be evaporated, do so, and add to the nearly dry residue, alcohol and chloride of platinum. As salts of potash produce with chloride of platinum a similar precipitate, the following test must be made in case of doubt. Wash the yellow precipitate well with alcohol, mix it in a small retort or large test-tube, with soda and quick-lime and water, heat the mixture, and let the evolved gas pass by means of a bent glass tube through alcohol, containing a few drops of hydrochloric acid. This acidulated alcohol will show the presence of ammonia, when tested with chloride of platinum.

4. Tartaric acid causes in ammoniacal solutions a white precipitate of bitartrate of ammonia, easily soluble in free alkalies, free mineral acids, and hot water. Salts of potash and tartaric acid form a similar precipitate, which can be distinguished from the above as stated under 3.

§ 18. Potassa,

(K O).

In healthy urine, is in combination with sulphuric, phosphoric and hydrochloric acids.

1. Potash, its hydrate and its salts, cannot be volatilized by means of a spirit lamp. Potash and its carbonate are deliquescent when exposed to the air, forming an oily fluid, which becomes hard by absorption of carbonic acid.

2. Nearly all salts of potash are soluble in water; and colorless, if the acid be so. Neutral compounds of potash and a strong acid, do not change vegetable colors.

3. Chloride of platinum produces in neutral and acid solutions of a salt of potash, a heavy yellow crystallized precipitate of the double chloride of platinum and potassium, in concentrated solutions at once, is diluted after some time, presence of a free acid favors its formation; it is soluble in water with difficulty, in alcohol insoluble. This reaction is most delicate, when the aqueous solution of the potash salt and chloride of platinum is evaporated nearly to dryness, and alcohol added, the double chloride of platinum and potassium remains undissolved. The process of distinguishing it from the chloride of platinum and ammonia was stated before under ammonia.

4. Tartaric acid causes in neutral or alkaline solutions of salts of potash, (enough acid must be added to make it strongly acid,) a white, quickly sinking, granulous, crystalline precipitate of bitartrate of potash. Violent shaking and addition of alcohol favors its formation; free alkalis and free mineral acids dissolve it; in cold water it is hardly soluble, but more soluble in hot water. If acid solutions of a salt of potash are to be tested, the acid is to be first neutralized by carbonate of soda.

§ 19. Soda.

(Na O).

Is found in urine, combined with hydrochloric and sometimes with phosphoric acid.

1. Soda, its hydrate and salts, show nearly the same properties and reactions as the corresponding salts of potash.

2. Antimoniate of potash produces in neutral and alkaline solutions of it, a white crystallized precipitate of antimoniate of soda, in concentrated solutions at once, in diluted after some time; violent shaking favors its formation. If after the addition of the reagent, the fluid be stirred with a glass rod in such

a way as to touch the side of the glass vessel containing the mixture, the course of the glass rod on the glass vessel will be visible, the precipitate forming first on the places where the rod rubbed the vessel. The presence of neutral salts of potash does not interfere with the formation of the precipitate, but carbonate of potash does; in such a case it is necessary to add hydrochloric or acetic acid until it shows only a little alkaline reaction. Acid solutions are first to be neutralized with potash.

3. Soda-salts dissolved in alcohol, color the flame of alcohol strongly yellow.

4. Chloride of platinum causes no precipitate.

§ 20. Earthy Phosphates.

(Phosphate of Lime. $P O_5$ 2 Ca O. And Phosphate of Magnesia. $P O_5$ 2 Mg. O.)

Ammonia in excess precipitates the earthy phosphates; after standing twelve to twenty-four hours, they are all deposited, and may be separated by filtering, they will remain upon the filter; their quantity may be determined by burning them with the filter, and weighing the residue.

To detect them separately, proceed as follows—

a. *Lime*. 1. Sulphuric acid and sulphate of soda produce in concentrated solutions of lime salts, a white precipitate of sulphate of lime (gypsum), soluble in about 500 parts of cold water; in very dilute solutions, sulphuric acid causes no precipitate, but it does cause it at once when alcohol is added.

2. Oxalic acid causes in neutral, even very dilute, solutions of salts of lime, a white precipitate of oxalate of lime, easily soluble in hydrochloric and nitric acids, but not in acetic and oxalic acids. Addition of ammonia hastens and augments this precipitate.

b. *Magnesia* and its hydrate are white voluminous powders, nearly insoluble in cold water, and in warm water still more insoluble.

2. Some of its salts are easily soluble in water, others are not; the soluble salts have a bitter taste; the insoluble salts are easily dissolved by hydrochloric acid.

3. Phosphate of soda produces in solutions of magnesia, when ammonia is added, a white, crystalline precipitate of the double salt of basic phosphate of ammonia and magnesia.

To obtain separately all these salts, add to fresh urine a few drops of ammonia, dissolve the precipitate in some acetic acid, all will be dissolved except some uric acid; add now a concentrated solution of oxalate of ammonia, which will precipitate all the lime as oxalate of lime, after twenty-four hours' standing, filter and add to the filtered fluid, ammonia in excess, which throws down all magnesia as the double salt of phosphate of ammonia and magnesia.

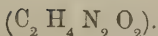
§ 21. Iron.

(Fe.)

It is not yet quite certain in what combinations iron occurs in human urine; it may be as a chloride, or in combination with an organic substance. Ferridcyanide of potassium produces with protosalts of iron a very deep blue precipitate; in very much diluted solutions it causes only a dark bluish green color.

To detect iron in urine, evaporate fresh urine to dryness, burn the residue at a red heat, add a little pure metallic zinc, and pure hydrochloric acid; the zinc converts the persalt into a protosalt of iron. When the zinc and the dry residue is all dissolved, filter, and add a little ferridcyanide of potassium, which will cause the deep blue precipitate, which is insoluble in hydrochloric acid.

§ 22. Urea



Crystallizes in white, clear, silky, striated prisms; if crystallized too fast, it forms white needles. See plate I., fig. 6.

It has no smell, but a bitter, cooling taste like nitre.

In water and alcohol it is easily soluble, in ether nearly insoluble. It does not change blue nor red litmus-paper.

If urea be heated on a piece of platinum it melts, ammonia is evolved, and at a stronger heat it burns without leaving any residue.

Strong mineral acids, and the hydrates of the alkalis decompose urea to ammonia and carbonic acid. The same changes are produced by fermenting substances; the mucus of the bladder and extractive matter of the urine may act as such.

Nitric acid added to a concentrated solution of urea forms white, shining scales, or sometimes distinct crystals of nitrate of urea. See plate II., fig. 7. It is easily soluble in water, soluble in alcohol; a watery solution of it is decomposed by boiling into carbonic acid, carbonate of ammonia, nitrous oxide and water.

Oxalic acid forms with it long, thin, scaly crystals of oxalate of urea. See plate II., fig. 8.

To obtain urea from urine, evaporate fresh urine to a syrup, exhaust the cold residue with alcohol, evaporate the alcoholic extract, add from one and a-half to twice its volume of pure nitric acid, and put it upon ice. After three to four hours you will have the crystals of nitrate of urea.

Urea as such may be obtained by mixing fresh urine with (about one-half its volume of) a solution of nitrate of baryta, as long as it causes a precipitate of phosphate and sulphate of baryta; the filtered fluid is to be evaporated to dryness; the residue extracted with alcohol; the alcoholic extract evaporated very slowly, when the urea will crystallize in colorless needles.

Detection of urea in other animal substances.

In blood.—Mix three or four ounces of fresh blood or serum of blood, with nine to twelve ounces alcohol, which will precipitate all albuminous matter, filter and evaporate in a water-bath, when salts, fat, extractive matter, and some albuminous matter will be separated; extract again with alcohol and evaporate very carefully. It is best to evaporate on a watch crystal to a syrup; bring now one drop of this syrupy residue under a microscope together with a drop of nitric acid, when the characteristic crystals of nitrate of urea will be observed. If there should be any doubt about the nature of these crystals, use instead of nitric acid, oxalic acid, which will form oxalate of urea.

In the same way urea may be detected in *saliva*, *perspiration*, *bile*, *mucus*, and *serous fluids*, except that with fluids containing no albumen, the process of coagulation is not necessary.

It is sometimes necessary to extract the fatty matter first with ether.

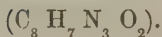
§ 23. Mucus

Is best detected by means of the microscope.

§ 24. Kreatine.



And Kreatinine.



Both these substances have been found in urine, but in very small quantities; they both crystallize; kreatine, as shown on plate II., fig. 11, and kreatinine, plate II., fig. 9.

The process of detecting their presence is so very difficult and tedious, that it is not thought necessary to give it here.

§ 25.—Coloring and extractive matter.

Extractive principle of the urine (to which the coloring matter belongs) is called the residue, remaining after all the characteristic constituents of urine have been separated. The larger portions of this so called extractive principle is a coloring matter, which differs from other constituents of urine in this: its elementary composition is different in different conditions of the life of the individual, while the elementary composition of urea, uric acid, &c., is constant under all conditions.

§ 26. Abnormal Urine.

Albumen.

Composition in 100 parts: C 53.5; H 7.0; N 15.6; O 22.0; S 1.6; P 0.4.

a. *Soluble albumen* is dissolved in water, with the aid of some salts, particularly alkalis, which seem to be constantly combined with the albumen in animal fluids. When decomposed by an acid, the acid forms combinations with the alkalis and albumen is precipitated. A solution of albumen exposed to a heat above 155° F., becomes turbid, milky, first at the surface, it then changes into a white flaky mass, no longer soluble; it *coagulates*. Addition of a few drops of acetic acid before heating, favors the coagulation, too much acid prevents it. This coagulum is insoluble in water, alcohol, ether, and in cold dilute acids. Boiling acetic and hydrochloric acids dissolve it.

Dilute nitric acid produces in solutions of albumen under all circumstances, a white precipitate of nitrate of albumen, soluble in an excess of water.

Neither acetic acid nor any other organic acid, except tannic acid, produce a precipitate.

Alcohol causes in solutions, not too much diluted, a precipitate of insoluble coagulated albumen, too much water prevents it.

Most salts of metals precipitate it, forming either a compound of a basic salt with albumen, or a mixture of a combination of the acid with albumen, and of the base with albumen. On the insolubility of these compounds depends the efficacy of the white of eggs as an antidote to metallic poisons.

To detect soluble albumen in a fluid, test first its reaction by litmus-paper, fill a test-tube half full with the fluid, and heat over a spirit-lamp. If the fluid be acid and albumen present, the above described coagulum will be formed; if it be alkaline, some acetic acid must be added before heating. Urine when heated deposits earthy phosphates, which appear like albumen, add therefore a few drops of nitric acid, if the deposit become dissolved it was not albumen, but phosphates. To guard against errors it is advisable to use different reagents, as nitric acid, corrosive sublimate, &c.

b. *Coagulated albumen* occurs sometimes in animal substances, it has all the properties of coagulated fibrine, from which it cannot be distinguished with any certainty. One of the many tests to distinguish these two substances is their behaviour towards acetic acid.

Fibrine, digested for a longer time with acetic acid, swells to a completely transparent jelly; albumen treated similarly is less affected, the formation of a jelly is not complete.

§ 27. Sugar

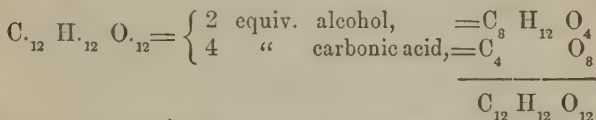


Occurs in urine only as *grape sugar*, *glucose*, *starch sugar*, *diabetic sugar*. It is a white, or whitish-yellow, granular mass, inodorous, of a taste less sweet than cane sugar, but sweeter than sugar of milk, soluble in $1\frac{1}{2}$ parts of cold water, a little soluble in alcohol, insoluble in ether.

Heated to a few degrees below 212° F., it loses 2 equivalents

of water and melts; at about 250° F. it evolves a sweetish smell; at a still higher temperature it swells up, turns brown, emits pungent vapors, and leaves a voluminous coal.

This sugar ferments directly: without undergoing any change it is converted into alcohol and carbonic acid, provided always that a ferment, as yeast, be present.



1. A solution of this sugar mixed with caustic potash and boiled, turns by degrees red-brown, emits a sweetish odor like molasses, which becomes still more perceptible when a few drops of nitric acid are added.

2. A solution of this sugar digested with dilute sulphuric acid, becomes slowly brown, when evaporated it leaves a black residue; it also becomes so with hydrochloric acid.

3. When to a solution of this sugar first caustic potash and then sulphate of copper be added, there is seldom a precipitate,—but if so, it soon again dissolves—the fluid turns beautifully blue; if this blue fluid be now heated, it turns orange, becomes turbid and throws down a yellow-red precipitate of sub-oxide or red oxide of copper.

4. When a solution of this sugar is mixed with a little yeast, and exposed to a temperature of from 60° to 76° fermentation takes place; alcohol is formed and carbonic acid gas evolved. That the escaping gas is carbonic acid gas may be shown by keeping the fermenting fluid in a bottle, through the cork of which a bent glass tube is fixed in such a way that one end of it dips into lime-water, the carbonic acid gas in passing through the lime-water forms an insoluble white precipitate of carbonate of lime. The test described under No. 3, is quite infallible, the solution of sulphate of copper must be added very gradually.

If urine contain only a very small quantity of sugar, or if it is to be detected in *blood, chyle, albumen*, &c., add a few drops of acetic acid, evaporate to dryness, extract with alcohol, evapo-

rate again, dissolve in water, add caustic potash, and then very carefully sulphate of copper, the above described reaction will take place. Another method is to precipitate the alcoholic solution with an alcoholic solution of a potash-salt, dissolve the so formed saccharate of potash in water, and then add sulphate of copper, the proper reaction will show the minutest trace of sugar with positive certainty.

§ 28. Fat

May be detected by extracting the dry residue of evaporated urine with ether, for its appearance under the microscope see plate II., fig. 10.

§ 29. Ammonia

May be discovered by hydrochloric or acetic acids, as stated before.

§ 30. Hæmatine, Globuline, Biliphaine, and Choleic Acid.

The detection of these substances, dissolved in urine, will be described hereafter.

§ 31. Undissolved Substances—Sediments.

a. *Sediments with organic formation :*

1. Mucus.
2. Exudation of fibrine.
3. Gluge's globules of inflammation.
4. Spermatozoa.
5. Red globules of blood.
6. Fungi.
7. Infusoria.

All these substances are detected by means of the microscope. See plate II., fig. 10.

b. *Sediments of purely chemical formation :*

1. Uric acid, see before.
2. Urates (of soda, ammonia, lime, potash and magnesia.)
3. Oxalate of lime.
4. Phosphate of ammonia and magnesia.
5. Tribasic phosphate of lime.
6. Bibasic phosphate of lime.
7. Cystine.
8. Uroglauoine and urhodine.

The knowledge of these sediments is of great importance in practical medicine, and may be detected according to the following methods.

§ 32. Urates.

1. *Urates of Potash*, and particularly the more common biurate, appear under the microscope as globules, covered with small, sharp prisms, or as an amorphous powder. See plate II., fig. 12, and plate III., fig. 13.

If there should be any doubt about the nature of these crystals, dissolve them in warm water, bring under a microscope a drop of the solution in contact with a drop of dilute hydrochloric acid, which will separate crystals of uric acid. All urates give with nitric acid and ammonia, the characteristic signs of uric acid.

2. *Urate of ammonia* does not occur often, it forms small, round masses. See plate III., fig. 14.

3. *Urate of lime* occurs almost exclusively in calculi, seldom in sediments. It is a white amorphous powder, soluble in water with difficulty; it gives with nitric acid and ammonia, the characteristic reaction of uric acid.

Uric acid, as a *sediment*, occurs only in *acid* urine of dark color. The sediment is rarely colorless, usually bright yellow, orange, or brown, of a sandy, crystalline appearance, the crystals can often be seen by the naked eye.

Urates occur almost exclusively in *acid* urine of a pale yellow, deep yellow, reddish, brown-red, brown, or copper color.

The color of these sediments are gray-white, white, rose-colored, brown-red, or scarlet.

These sediments appear often so very much like mucus, pus or blood, that they can only be distinguished by the microscope, by their solubility when heated, and by their reaction with nitric acid.

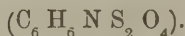
§ 33. Sediments of Salts of Lime, and of Phosphate of Ammonia and Magnesia.

Phosphate of lime occurs either as tri-basic phosphate, an amorphous powder, or as bi-basic phosphate in crystals. See plate III., fig. 18.

§ 34. Oxalate of Lime

Is found in acid, neutral and alkaline urine. The color of urine, containing it as a sediment, is that of amber. See plate III., fig. 19. The chemical reactions have been given before.

§ 35. Cystine.



Was first discovered by Wollaston in a calculus; Mandl and Golding Bird assert they have found it dissolved in urine, from which they precipitated it with acetic acid. It is sometimes found as a sediment, mixed with urate of soda. It is a dirty yellow, transparent, irregularly crystalline mass; when pure, it forms colorless, transparent prisms. See plate IV. fig. 20. It is without taste and smell, insoluble in water and alcohol, soluble in mineral and oxalic acids, forming with them in most cases crystalline compounds. With acetic, tartaric,

and citric acids, it forms no combinations. Nitric acid decomposes it when boiled, transforming it into a dirty brown mass.

Caustic alkalies, the carbonates of the fixed alkalies and ammonia dissolve it easily; carbonate of ammonia does not dissolve it. The latter and carbonic acid gas precipitate it from its ammoniacal solutions; acetic acid does the same in alkaline solutions.

Heated on a piece of platinum it does not melt, but it burns with a bluish green color, emitting a pungent smell like prussic acid.

Cystine boiled with alkalies evolves ammonia and an inflammable gas, which burns with a blue flame.

In sediments it is easily distinguished by the microscope, but it must be recollected that uric acid sometimes forms similar crystals, which may be distinguished from each other by testing with nitric acid, which turns uric acid beautifully scarlet, but cystine dirty brown. Urates are soluble in water, cystine not.

Urine containing cystine is said to be sometimes of a normal straw color, sometimes of a deep green color, to have an oily appearance, and a peculiar penetrating smell.

§ 36. Systematic Analysis of Sediments.

When sediments occur in urine, we have to deal with pathological productions, and these are so very various that it is impossible to give a process suitable in all cases.

The following is given as an example.

Test the urine with litmus-paper; in *acid* urine we can detect by the microscope mucus, pus, epithelium, spermatozoa, &c., urate of soda, oxalate of lime, and cystine; in *alkaline* urine the microscope alone will detect the double salt of ammonia and magnesia, and urate of ammonia.

Pour the urine on a filter, after all the fluid has drained off, wash the filter with warm water, and collect the warm filtered fluid in another vessel, this will, on cooling, form a deposit of

urates which may be distinguished by the microscope. Supposing them to consist of urate of ammonia, urate of soda, and urate of lime, they may be separated in the following way : pour the fluid with its sediment on a filter, after the fluid has been filtered off, put the funnel with its filter on another glass, wash the filter and contents with water containing hydrochloric acid. Uric acid is separated, and remains upon the filter. The filtered fluid contains chloride of sodium and chloride of lime ; add ammonia, dissolve the precipitate caused by it, in acetic acid, add oxalate of ammonia, which will throw down the lime as oxalate of lime ; filter, add sulphuric acid in excess, and evaporate, when sulphate of soda will remain.

Pour upon the residue upon the first filter, warm dilute acetic acid, which will dissolve phosphate of lime and the double salt of phosphate of ammonia and magnesia, which may be separated as described before.

Wash the residue upon the filter with water, mix with a few drops of hydrochloric acid and water, and filter. The filtered fluid may contain oxalate of lime and cystine. Add ammonia in excess, if it become turbid, oxalate of lime is present, filter again. If it do not become turbid, oxalate of lime is not present. Pass through the filtered fluid a stream of carbonic acid gas, a precipitate shows the presence of cystine, no precipitate its absence.

The residue yet remaining on the first filter may now contain urrhodine, uroglaucone, uric acid, mucus, organic formations, &c. Extract the filter and residue with boiling ether ; a red color of the ether shows the presence of urrhodine. Boil the residue with alcohol ; a blue color shows uroglaucone. Mix with the now remaining residue a diluted solution of the neutral phosphate of soda, filter and wash with water ; add to the filtered fluid hydrochloric acid in excess, which will separate all uric acid. What now remains are organized substances.

§ 37. Concretions, Urinary Calculi.

In urinary calculi we distinguish

1. The *essential parts*, as uric acid, cystine, earthy phosphates, oxalate of lime, &c.
2. The *cement* or uniting substance, as mucus, extractive matter, &c.

The analysis commences with the study of their physical properties; it must be recollected that calculi consist very often of concentric layers, which it will be sometimes necessary to analyze separately. We distinguish

1. *Completely combustible* stones, which may contain uric acid, urate of ammonia, hippurate of ammonia, xanthine, cystine, &c.

2. *Partly combustible* calculi, may contain, urate of soda, urate of lime, and all substances under 1 and 3.

3. *Incombustible* calculi, which contain no organic matter.

1. Calculi partly or entirely of *uric acid* are the most frequent. They are generally hard, of a red-brown, brown-yellow, seldom white color; surface smooth, or studded with round warts, fracture crystalline or earthy, consisting of concentric layers.

2. Calculi consisting only of *urate of ammonia* are rare, generally free uric acid is mixed with it. They occur mostly in children, and resemble No. 1.

The following table is very convenient in analysing calculi:

Analysis of Urinary and Renal Calculi.

1. *Calculi which burn without leaving a residue, when heated on a piece of platinum.*

<p><i>a.</i> The solution in nitric acid, (of the calculus) when evaporated, is colored <i>red</i> by ammonia.</p>	<p><i>b.</i> The solution in nitric acid, when evaporated, is <i>not</i> colored <i>red</i> by ammonia.</p>	<p>It burns with a bright flame.</p>	<p>The sample is of a brown color, crumbling, when burned emitting an animal smell.</p>
<p><i>α.</i> With caustic potash, no evolution of ammonia: <i>uric acid</i>.</p>	<p>when evaporated turning <i>yellow</i>, insoluble in carbonate of potash: <i>ammoniac</i>.</p>	<p>is distinctly crystalline, soluble in hot alcohol, from which it crystallizes on cooling, in scales shining like mother of pearl; insoluble in caustic potash, from this solution acetic acid will precipitate it, acetic acid in excess dissolves it, and ferrocyanide of potassium precipitates it again: <i>fibrine</i>.</p>	<p>little soluble in alcohol and water, soluble in potash with dark color. Nitric acid causes in this solution the changes of colors peculiar to the coloring matter of bile: <i>coloring matter of bile</i>.</p>
<p><i>β.</i> With caustic potash, evolving ammonia, <i>urate of ammonia</i>.</p>	<p>when evaporated turning <i>dark brown</i>, soluble in carbonate of ammonia and caustic ammonia, crystallizing from the latter solution in minute croscopic six sided scales: <i>cystine</i>.</p>	<p>when burning evolves an odor like burned hair, and swells up; soluble in caustic potash, from this solution acetic acid will precipitate it, acetic acid in excess dissolves it, and ferrocyanide of potassium precipitates it again: <i>fibrine</i>.</p>	<p>soluble in alcohol; the solution of a bitter taste, with sugar and sulphuric acid producing a beautifully violet red color: <i>choleic acid</i>.</p>

2. *Calculi which leave a considerable residue, when heated upon a piece of platinum.*

1. The residue melts before the blow-pipe.	2. The residue does not melt before the blow-pipe.	3. The sample gives with nitric acid and ammonia, the reaction of uric acid, but leaves a residue when calcined.
<p><i>a.</i> Effervesces neither before nor after burning with acids; soluble in hydrochloric acid, ammonia precipitates it, oxalate of ammonia causes a white, flaky precipitate: <i>neutral phosphate of lime.</i></p> <p><i>b.</i> emits when heated, an ammoniacal smell, dissolves without effervescence in acetic acid, from which solution ammonia precipitates it in a crystalline form: <i>phosphate of ammonia and magnesia.</i></p>	<p><i>a.</i> residue white, not alkaline, otherwise behaving like neutral phosphate of lime: <i>basic phosphate of lime.</i></p> <p><i>b.</i> the fresh sample insoluble in acetic acid, soluble without effervescence in mineral acids, ammonia precipitates it. The residue (after burning) is alkaline, and effervesces with acids: <i>oxalate of lime.</i></p> <p><i>c.</i> the sample when burned, emits a strong white light, effervesces before burning with acids, is precipitated from these solutions after being neutralized by oxalate of ammonia: <i>carbonate of lime.</i></p>	<p><i>a.</i> melts before the blow-pipe, turning the flame intensely yellow color: <i>urate of soda.</i></p> <p><i>b.</i> behaves like <i>a</i>, but does not turn the flame yellow, chloride of platinum causes in its solution in hydrochloric acid a yellow precipitate: <i>urate of potash.</i></p> <p><i>c.</i> does not melt before the blow-pipe, and behaves after calcining as carbonate of lime: <i>urate of lime.</i></p> <p><i>d.</i> does not melt before the blow-pipe, the residue is soluble with little effervescence in dilute sulphuric acid, and is precipitated from this solution by potash or phosphate of soda and ammonia: <i>urate of magnesia.</i></p>

Note to 1 and 2. To test for uric acid or urates, proceed as follows—

Put a small part of the calculus on a piece of platinum over a spirit lamp, and blow with a blow-pipe upon it. When it consists of pure uric acid, the coal will burn completely, evolving an odor like prussic acid. Such being the case, treat another part of the calculus with nitric acid and ammonia, and a third part may be dissolved in caustic potash, when the calculus consists of pure uric acid, this solution will take place without the evolution of ammonia. The solution in potash may now be oversaturated with hydrochloric acid, when after some time uric acid may be examined by the microscope.

Should the calculus consist of urate of ammonia, it will behave in the same way when burned. It may be easily distinguished from pure uric acid by its emitting ammonia when burned, and still more so when dissolved in caustic potash, its ammonia may be detected by chloride of platinum, hydrochloric and acetic acids; it is soluble in boiling water, and is deposited on cooling.

3. *Urates with a fixed base* have only been found in calculi combined with uric acid, from which they may be separated by boiling water.

4. Calculi of *oxalate of lime* are common, generally round, often covered with warts (mulberry stones,) dark brown, tolerably large; sometimes small, paler, and smooth, having the appearance of hemp seed.

5. Calculi of *earthy phosphates* are whitish, earthy, cretaceous, sometimes porous and scaly.

6. A calculus, analysed by Wöhler, consisting of *xanthine*, was on the surface light brown, with a few spots of white; fracture dull; composed of concentric layers; became, on rubbing, glistening like wax, hardness like calculus of uric acid.

Xanthine, ($C_5H_2N_2O_2$) or uric oxide, forms, when pure, a pale yellowish mass, which shines like wax when rubbed; heat decomposes it without melting, emitting much prussic acid. It is nearly insoluble in water, alcohol and ether; moderately heated with nitric acid it is dissolved, without evolving gas, leaving, after evaporation of the acid, a lemon-colored resi-

due, soluble with a deep red color in ammonia and potash; in a solution of the residue in potash, sal ammoniac causes a yellow, carbonic acid, a white precipitate.

From guanine this substance may be distinguished by the former not being able to form salts with acids, and its insolubility in hydrochloric acid.

From cystine it is different in its being unable to crystallize, and its insolubility in hydrochloric and oxalic acids.

Calculi containing xanthine may be dissolved in potash, and the xanthine be precipitated by carbonic acid gas.

7. Calculi of *cystine* are rare, they are of a yellowish color, their surface is smooth, fracture crystalline.

8. Calculi of *indifferent organic substances* are very rare.

Silica is very seldom contained in calculi.

Carbonate of lime and *carbonate of magnesia* are sometimes found in urinary and renal calculi.

§ 38. Milk.

Fresh human milk is a white, commonly alkaline fluid, consisting of water and solids, the latter are: caseine, butter, sugar of milk; soluble salts, viz.: potash, soda, lime, and magnesia, combined with chlorine, sulphuric, phosphoric and carbonic acids; and small quantities of iron and silica.

1. *Caseine, or curd of milk*, C 53.83; H. 7.15; N 15.65; O. 22.53; S. 0.84). It is, when pure, insoluble in water; but in milk it is rendered soluble by combination with a little alkali. Its solution is immediately coagulated by *delute acids*, which combine with the precipitated caseine. The spontaneous coagulation of milk is due to the formation of lactic acid from the sugar of milk, by the agency of a portion of the caseine in a state of incipient decomposition.

Acetic and *lactic* acids precipitate caseine; acetic acid in excess dissolves this precipitate again. *Alcohol* causes a precipitate, soluble in much water. *Tannic acid* and the salts of metals, as corrosive sublimate, and alum, throw it down, so do *chloride of calcium*, and *sulphate of magnesia*.

The best test, however, for caseine is *rennet* (prepared by digesting the lining membrane of a calf's stomach in water), it precipitates caseine in any fluid, particularly when the fluid is made alkaline by a little soda. Its reactions and properties are so much like those of albumen, that it is difficult to separate them when both occur in the same fluid. The best way is to add to the fluid chloride of ammonium, boil a short time to precipitate the albumen, filter and add chloride of calcium, or sulphate of magnesia; when a precipitate appears on cooling, filter again; boil the fluid, a precipitate, shows the presence of caseine, which may be tested by rennet.

2. *Butter*, too well known to need a description. The best mode of detecting butter and all fatty substances, is by means of the microscope, if seen once they can never be mistaken. Butter is a compound of different fats, it owes its peculiar flavor to *butyrine*; when saponified, it is transformed into glycerine, and a new acid, the *butyric acid*, which causes the strong smell of rancid butter. Butyric acid is represented on plate IV., fig. 24.

3. *Sugar of milk* ($C_{12} H_{10} O_{10} + 2 H O$). is obtained by evaporating the whey of milk, it forms semi-transparent prisms, soluble in 6 parts of cold, and $2\frac{1}{2}$ parts of hot water, insoluble in absolute alcohol, but soluble in alcohol of 0,85 spec. gravity. Dilute mineral acids change it into grape sugar. Caseine in a state of incipient decomposition, transforms it into lactic acid.

§ 39. Quantitative Analysis of Milk.

A. *Water and Solids*.—Dry finely pulverized gypsum or plaster-of-paris perfectly, put it into a dry, well-corked bottle, and weigh the bottle with the gypsum. Pour about 2 or 3 drachms of fresh milk in a weighed porcelain crucible, and weigh again to ascertain the accurate weight of the milk, add to it about $\frac{1}{2}$ drachm of the dry gypsum, and weigh again to get the weight of the gypsum added, the gypsum is used to facilitate the drying and pulverizing of the residue. Evaporate to dryness in a water bath, stirring constantly with a glass-rod.

After it has been completely dried, weigh the crucible with contents; from this weight subtract the weight of the crucible and gypsum, the rest is the weight of the solids, and this deducted from the fresh milk, leaves the weight of the water.

B. *Butter*.—Dry a thin small glass flask, a well fitting cork, and a small filter, well, and weigh these three articles. Put the greater part of the residue, obtained under A, into the flask, and weigh again, the additional weight is the weight of the milk and gypsum powder. Pour ether into the flask, and boil by holding the flask over boiling water, decant and filter through the weighed filter, repeat this operation as long as the ether dissolves anything. Dry the flask, residue, cork and filter and weigh again, the lost weight is the weight of the butter.

C. *Sugar of Milk and Salts soluble in Alcohol of 0.85 spec. grav.*—Pour alcohol of 0.85 sp. gr. into the same flask, apply heat, and filter through the same filter, repeat this operation as long as alcohol takes up anything. Dry the flask, cork and filter, and weigh, the lost weight is the weight of the sugar of milk and salts, soluble in alcohol of 0.85 sp. gr.

D. *Caseine and Salts insoluble in Alcohol of 0.85 sp. gr.*—The weight of gypsum, subtracted from the residue from C., is the weight of caseine and the above salts.

E. *Incombustible Salts*.—Evaporate 2 or 3 drachms of fresh milk to dryness, and calcine the residue.

F. *Salts soluble and insoluble in Alcohol of 0.85 sp. gr.*—To know their amount it is necessary to find the weight of the sugar of milk alone. Evaporate about 3 drachms of fresh milk to dryness; heat a porcelain crucible over a spirit-lamp, put into it the milk powder by degrees, and burn or char it, until no more empyreumatic vapors are evolved, exhaust the residue with warm water and then filter; dry the exhausted residue, and calcine it with the filter, this gives the weight of the salts insoluble in water. Evaporate the filtered fluid to dryness, heat for a moment to a red heat and weigh, it gives the weight of the salts soluble in water. These salts extract with alcohol of 0.85 sp. gr., heat the residue, not dissolved by the alcohol, to redness, the residue and the salts insoluble in water, give the salts insoluble in alcohol of 0.85 sp. gr. These, subtracted

from the weight of the caseine and salts insoluble in alcohol of 0.85 sp. gr., (obtained under D.,) give the weight of the caseine. The soluble salts deducted from the weight of the sugar of milk and salts, soluble in alcohol of 0.85 sp. gr. (obtained under C.), give the weight of the sugar of milk.

The nature of the different salts may be ascertained by analysing charred and calcined milk, as described under urine.

Calculation of an Analysis of Milk.

A. Solids and Water :

Suppose the weight of the crucible be 20 grammes, milk 10 grm., gypsum 2 grm.; crucible + residue 24 grm.; the residue therefore, 4 grm.; deduct gypsum 2 grm., leaves for solids 2 grm.; and $10 : 2 = 1000 : x$; $x = 200$; or 1000 parts of fresh milk contain 200 parts of solids, and 800 parts of water.

B. *Butter* :

Cork + flask + filter + milk and gypsum	. = 12.500	grms.
Deduct cork + flask + filter = 9.000	
	<hr/>	
Milk and gypsum,	= 3.500	

After exhausting with ether, weight of

Cork + flask + filter + residue	=	12.105
Weight before	=	12.500

Butter	=	0.395

In 4 grms. residue are 2 grms. gypsum, therefore in 3.500 grm., 1,75 grm. gypsum and 1,75 grm. dried milk; therefore: 1.750 milk : 0.895 butter = 200 : + = 45.143. In 1000 parts of milk, therefore, there are 45.143 parts of butter.

C. Sugar of Milk and Salts soluble in Alcohol of 0.85 sp. gr.

Cork + flask + filter + milk and gypsum	=	12.105 grms.
After extraction with alcohol	=	11.775

$$\text{Sugar of milk and the above salts:} = 0.330$$

$$1.75 : 0.330 = 200 : x = 36.714.$$

1000 parts milk contain, therefore, 36.714 of sugar of milk and salts, soluble in the above alcohol.

D. Caseine and Insoluble Salts.

Cork + flask + filter + milk and gypsum-powder	=	11.775 grms.
Cork + flask + filter	=	9.000

$$\text{Caseine and insoluble salts} = 2.775$$

$$\text{Gypsum:} = 4.750$$

$$\text{Caseine and insoluble salts:} = 1.025$$

$1.75 : 1.025 = 200 : x = 117.143$. 1000 parts of milk, therefore, contain 117.143 parts of caseine and insoluble salts.

E. Incombustible Salts, and Salts Soluble and Insoluble in Alcohol of 0.85 sp. gr.

Calculated as before, we find:

In 1000 parts: 10.121 salts.

Of these soluble in alcohol, 5.000 grms.

In water and alcohol insoluble, 5.121

The composition of the milk is consequently in 1000 parts:

Water,	800.000
Solids,	200.000

Total,	1000.000
--------	----------

Solids :

Caseine and salts insoluble in alcohol, . . .	117.143	
Butter,	45.143	
Sugar of milk and salts soluble in alcohol of 0.85 sp. gr.	36.714	
		<hr/>
Total,	200.000	
		<hr/>
Water,	800.000	
Caseine,	112.022	} parts of solids 200,000
Butter,	45.143	
Sugar of milk,	32.714	
Soluble salts (in alcohol of 0.85), . . .	5.000	
Insoluble salts (in alcohol and water), .	5.121	
		<hr/>
	10000.000	

§ 40. Bile.

There is perhaps no other animal fluid of the composition of which there is so much uncertainty, as bile. It may be considered to consist of the soda salts of two acids—of which, one, cholic acid, contains no sulphur, and the other, choletic acid, contains sulphur;—of a peculiar coloring matter; fats; cholesterine; mucus; mineral acids and water, or :

1. Water.**2. Organic substances :**

Glycocholate of soda,	}	Essential constituents of bile.
Taurocholate of soda,		
Coloring matter,	}	Bilifalvine,
		Biliverdine,
		Biliphaine.

Fats: Elaine and Margarine,
Cholesterine and Mucus.

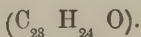
3. *Inorganic substances* : Potash, soda, lime, magnesia, combined with sulphuric, phosphoric and hydrochloric acids ; traces of iron, manganese, silica.

Small quantities of bile may be detected by mixing the suspected fluid with a concentrated solution of sugar and sulphuric acid, a *purple* color shows the presence of bile. To detect bile in *blood*, add to a little serum a few drops of acetic acid, evaporate in a water bath to dryness, and exhaust the residue with alcohol of 0.85 spec. grav. Evaporate the solution of alcohol nearly to dryness, mix with some water in a test-tube, and add a few drops of a solution of sugar (1 part of sugar, and 4 parts of water). Add now pure sulphuric acid by drops, without heating the mixture above 120°. If bile be present, the fluid becomes first turbid, then clear and yellow, soon pale red, scarlet, and finally beautifully purple ; it is sometimes several minutes before this reaction takes places. In *urine* it may be detected in the same way, if it contain no albumen, if it does, the albumen must first be removed.

To detect bile in *fæces*, dry them, extract with alcohol, and proceed as stated before.

In this way can be detected all the essential constituents of bile except taurine, cholestérine, and the coloring matter, these do not show the change of color described above.

§ 41. Cholesterine



Is a crystalline fat, soluble in ether, fatty oils and hot alcohol, insoluble in water. It is easily recognised under the microscope ; see plate IV., fig. 21 and 22. It is without taste and smell, neutral, melts at 310°, smells when burnt like geranium. It cannot be saponified ; when combined with other fats it may be separated by combining the other fats with oxide of lead, and dissolving the cholesterine in boiling alcohol.

Cholesterine is colored red by sulphuric acid, especially when gently heated.

When cholesterine occurs in solid animal substances, it is detected by the microscope; dissolved in fluids, as blood, bile, &c., in the following way: evaporate the animal fluid to dryness, extract with ether, evaporate, extract the residue with cold alcohol; that which is not dissolved by cold alcohol, boil in alcohol containing a little potash; filter the fluid hot, and evaporate the alcohol, constantly adding water, the residue is then boiled repeatedly with water, and at last dissolved in hot alcohol, which, on cooling, will deposit the crystals of cholesterine. Most biliary calculi contain cholesterine, from which it may be easily extracted by boiling them in alcohol.

§ 42. Fats which can be saponified.

1. *Elaine* remains fluid below the freezing point, and forms, when saponified, an acid, which becomes hard only below the freezing point.

2. *Margarine* gives, when saponified, an acid, which melts at 140° ; it is harder than elaine.

By decomposition of bile, different acids are formed, all of which show the reaction with sugar and sulphuric acid described before.

§ 43. Coloring matter of bile.

1. *Biliphaine*, brown.

2. *Biliverdine*, green.

3. *Bilifulvine*, yellow.

The properties and detection of these colors are as follows:

1. *Biliphaine* is a dark brown mass, does not melt when heated, but burns, leaving much coal, which, after long continued heating, burns without a residue. It is slightly soluble in boiling water. Soluble in boiling alcohol, coloring it dark brown, which color turns by degrees green. Boiling dilute hydrochloric acid dissolves a little with blue color. Carbonates of alkalies and caustic alkalies dissolve it with yellow or brown color.

Detection.—Mix the fluid with a few drops of nitric acid, so that it turn green. Now let twenty to thirty drops of concentrated sulphuric acid run down carefully on the side of the vessel, so that it, the sulphuric acid, sink to the bottom without mixing with the fluid. If biliphaine be present, differently colored strata will appear above the sulphuric acid, the lowest will be yellow, the next blue, and the top one green. If the fluid contain albumen, it must be coagulated by heat. Biliary concretions must be pulverized, boiled with alcohol, ether and dilute acid; what remains undissolved, must be dissolved in ammonia and tested as above.

2. *Biliverdine*.—Biliphaine is transformed by absorption of oxygen into biliverdine; it is beautifully green, without taste and smell. When exposed to heat, it, like biliphaine, does not melt, but burns, leaving much coal, which can be burned completely, but with great difficulty. Cold water and ether do not dissolve it. Hot water dissolves a little. Alcohol, solutions of caustic alkalies and carbonates of alkalies, dissolve it, giving rise to a beautifully green color. Acids precipitate it from the latter solutions with dark green color. When biliverdine and biliphaine are present at the same time, it is impossible to show the presence of biliverdine separately.

3. *Bilifulvine* is a shining yellow substance, soluble in water, insoluble in alcohol and ether, and of which we know as yet very little.

These coloring matters may be detected in the same way in the perspiration, saliva and blood (serum.)

To detect them in biliary concretions, dissolve these in caustic potash, and proceed as described.

§ 44. Taurine

C.	19.20
H.	5.60
N.	11.20
S.	25.60
O.	38.40

100.00

Is a production of decomposition caused by acids or putrefaction in bile ; it contains 25 per cent. of sulphur, forms colorless, regular prisms, (see plate IV. fig. 23) soluble in $15\frac{1}{2}$ parts of water and 573 parts of alcohol of 0.835 spec. grav. ; insoluble in absolute alcohol and ether ; without reaction on vegetable colors Exposed to heat, it evolves sulphurous acid ; boiled with caustic alkali, it does not become black, evolves ammonia, and leaves sulphurous acid and acetate of potash.

§ 45. The inorganic substances

Of bile are determined by drying and charring bile, extracting with water, then with hydrochloric acid, analysing these different solutions and the completely calcined residue.

§ 46. Blood.

The composition of blood is very different when different kinds of food and drinks are used and at different times of the day : blood changes rapidly with the external and internal conditions of the organism. A *complete* analysis of the blood can at the present time not be made, neither is it necessary. Some compounds in the blood are not yet well known, others change very rapidly.

Many substances present in the blood, have already been described here, as : albumen, bile, sugar, urea, ammonia, &c. Those not yet treated of are fibrine, globuline and hæmatine.

a. Fibrine.

Fresh, living blood contains dissolved fibrine, which, on being taken from the body, gradually coagulates, passing into the so-called insoluble modification. It is impossible to analyze soluble fibrine as such ; when present in a fluid, it shows itself by spontaneous coagulation.

Fibrine may be separated from the blood by stirring fresh blood for fifteen to twenty minutes, expressing the lump of fibrine with dry fingers, and washing it with water until it is perfectly white. When yet moist, it is a white, elastic, amorphous mass of fibres; when dry, yellowish, friable. It is insoluble in water, alcohol and ether; soluble in caustic potash, less soluble in ammonia. Nitric acid colors it yellow, and dissolves it when heated. Concentrated sulphuric acid makes it swell, and dissolves it when heated. Fuming hydrochloric acid colors it blue, when exposed to the air; when heated, it dissolves it with yellow color. Common phosphoric acid makes it swell, and this swollen mass is soluble in warm water. Lime and baryta form with it compounds which are soluble in water. It is said to be soluble in a solution of nitre.

The detection of the fibrine of blood is very difficult. If in animal fluids a coagulum is formed spontaneously, which is insoluble in water, containing one tenth per cent. hydrochloric acid, but swells only to a gelatinous mass, the presence of fibrine of blood is demonstrated. The fibrine of flesh is completely soluble in water containing one tenth per cent. of hydrochloric acid.

b. Globuline

Mixed with hæmatine forms the contents of the red globules of blood. Purer and in a much more concentrated solution it occurs in the crystalline lens of the eye.

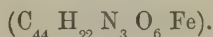
Globuline is known in a soluble and a coagulated form. Soluble globuline forms a transparent, yellowish, brittle mass, which can be easily reduced to a white, tasteless and inodorous powder; this powder, when first put in water, swells, but is finally dissolved to a thick fluid. A watery solution of it, when heated, becomes turbid at 163° , milky at 182° , and coagulates at 200° . Albumen coagulates at a temperature of between 140° and 158° .

A very little acetic acid makes a solution of globuline opalescent. Neither acetic acid nor ammonia precipitate it. But

when the acid solution is accurately neutralized by ammonia, it is immediately precipitated.

Alcohol precipitates watery solutions of globuline; this precipitate, as that of albumen obtained in the same way, is insoluble in water, but the coagulum of globuline is partly soluble in diluted alcohol, which solubility distinguishes it from albumen. It is very difficult to distinguish globuline in fluids, containing albumen and caseine. It differs from albuminous substances in being precipitated from its acid solutions by neutralization.

c. Hæmatine.



The coloring matter of the blood may be obtained, after Berzelius, by mixing fresh blood with a concentrated solution of sulphate of soda, and by filtering this mixture; the red globules of blood remain upon the filter; wash them with the solution of sulphate of soda, boil the residue in alcohol, which contains a little sulphuric acid, repeat this as long as the alcohol becomes colored; add to the still warm solution a little carbonate of ammonia; filter after some time from the deposit. Evaporate the filtered fluid, when hæmatine will be precipitated as fast as the ammonia evaporates. Remove the fat by means of ether and then dry. It is a black-red, inodorous and tasteless substance, with a somewhat metallic lustre, insoluble in water, alcohol and acetic ether, but soluble in these three fluids with blood-red color, when ammonia is added to them.

Olive oil and oil of turpentine dissolve it with red color.

Nitric acid dissolves it with red-brown color, decomposing it. Diluted mineral acids form, with hæmatine, compounds insoluble in water, but soluble in alcohol.

To detect hæmatine, examine under the microscope,—the presence of the red globules proves the presence of hæmatine. A red fluid may contain dissolved hæmatine; to find this, boil the fluid; if no coagulum be formed, add on cooling a little

white of eggs and boil again. Boil the red coagulum so long with fresh alcohol as the alcohol becomes red. Boil now with alcohol containing a few drops of dilute sulphuric acid. A red color of this last fluid shows the presence of hæmatine. If it do not become red, hæmatine may still be present, but it cannot be proved.

d. Albumen

may be shown by pouring one part of blood-serum in four parts of boiling water, when the albumen will coagulate; this is favored by adding a few drops of acetic acid.

To ascertain the different salts in the blood, the serum, the coagulum, (fibrine) &c., dry, burn and calcine them separately and analyze as in similar cases.

‡ 47. Chyle, lymph, serous exudations and similar albuminous fluids, saliva, gastric juice and pancreatic fluid.

The constituents of all these substances, known from the works on physiology and pathology, are detected in the way described under urine, milk, &c.

Saliva is said to contain sulpho-cyanide of potassium; a very delicate test for its presence is any of the persalts of iron, which produce a deep blood-red color with it.

‡ 48. Fæces

contain substances, which have been discussed in the preceding chapters.

‡ 49. Bones.

The inorganic substances of bones have all been treated of before. From the cartilaginous substance gelatine is extracted

by long continued boiling in water; the solution on cooling becomes a firm jelly. There are two modifications of this substance, *glutine* and *chondrine*. Glutine is obtained from bones, tendons, cellular membranes, and such permanent cartilages as are in the act of becoming bones by disease; it is found nearly pure in isinglass or fish-glue. Chondrine is obtained from cartilages and the cornea. Neither glutine nor chondrine are contained as such in the above structures; they are formed by long continued boiling. Pure glutine is yellowish, nearly transparent, hard, horny, brittle, inodorous and tasteless, swells in cold water, and forms with water a slimy fluid, which, on cooling, becomes a firm jelly. It is insoluble in alcohol and ether; alcohol precipitates it from its watery solutions in white flakes, which are soluble in much water. Concentrated sulphuric acid and caustic alkalies decompose it.

Tannic acid forms with it a very insoluble yellow precipitate.

All other organic and inorganic acids do not precipitate it, neither do alum, the salts of silver, copper, lead and iron.

Chloride of mercury and chloride of platinum produce a voluminous, white precipitate.

Chondrine has the same physical properties, but it is precipitated from its watery solution by alcohol, acetic acid, dilute sulphuric acid, hydrochloric, nitric, oxalic acids, alum, salts of iron, lead, copper and silver; chloride of mercury makes the solution only turbid.

To distinguish glutine from chondrine, wash the jelly with cold water, dissolve in warm water and add to different portions, acetic acid to one, alum to another and acetate of lead to a third. If these substances, added in small and large quantities, cause no precipitate, chondrine is not present; it is therefore glutine. If a precipitate be formed, glutine may be present as well as chondrine. Add to another portion, chloride of mercury in solution; a precipitate shows the presence of glutine.

§ 50. Ammonia in the air.

The best test for free ammonia is log-wood paper ; it is prepared as follows :

Take one ounce of fresh log-wood (that which is sold in the shops, already cut up, is not good) cut it as fine as possible, extract it with four ounces alcohol and twelve ounces water, add to this tincture from sixteen to twenty grains of alum, free of iron (instead of which four grains of blue vitriol may be used ; this causes the prepared paper to turn intensely blue when acted on by ammonia) and a filtered solution of three to four drachms of fused chloride of calcium, to which had been added enough hydrochloric acid to slightly redden litmus-paper. Add to the now turbid fluid one or four drops, or so much dilute hydrochloric acid as will cause the paper immersed in this fluid to appear, when yet moist, of the color of peach-blossoms. As long as the moist paper is purple, hydrochloric acid is wanting ; too much acid makes it yellow. The paper, to be used, must be free of iron and lime ; it is prepared in this way :—soak good letter paper for twenty-four hours in diluted pure hydrochloric acid, wash with water, containing a little hydrochloric acid, until every trace of iron is removed, wash now in a mixture of ammonia and water and dry carefully. Moisten the paper, purified in this way, with the tincture above described, dry quickly, and keep it in small, hermetically closed bottles, protected from light.

This log-wood paper possesses the greatest sensibility for ammonia only when freshly prepared ; it ought to be prepared with fresh tincture only.

It owes its sensibility for alkalies chiefly to the chloride of aluminium, the former converting the latter into basic chloride of aluminium, which forms with the coloring matter of the log-wood blue compounds.

Log-wood paper is colored blue by the carbonates, borates, acetates, butyrates of the alkalies and earths, and all other alkaline and earthy salts with feeble acids, even when the latter are present in excess ; it does not show that blue color with

the tartrates, citrates, lactates and all alkaline and earthy salts with stronger acids, when present in excess.

To detect ammonia in expired or atmospheric air, expose a slip of this log-wood paper moist to the air ; it will turn blue in a short time.

A single drop of a fluid, which contains the one hundred thousandth part of free ammonia, enclosed in a very small vial, turns a piece of log-wood paper suspended in the same vial, blue in a few hours. Three to twelve ounces of a fluid containing ammonia, thirty-two or even sixty million times diluted, are sufficient to turn this log-wood paper blue in three to twelve hours.

To detect ammonia in distilled water or similar fluids, put a few ounces of the fluid in a bottle, which is only half filled with it, add a little caustic potash, and suspend in the bottle over the fluid a slip of this paper ; when ammonia is present, it will turn blue in about thirty to sixty minutes.

Corks must not be used in these experiments, but well-ground glass stoppers, greased with some pure oil.



Fig. 1.



Fig. 2.



Fig. 3.

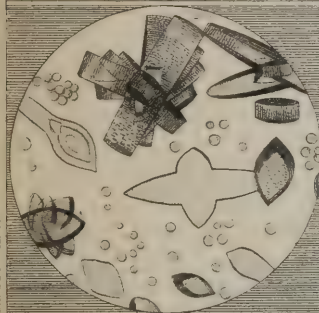


Fig. 4.

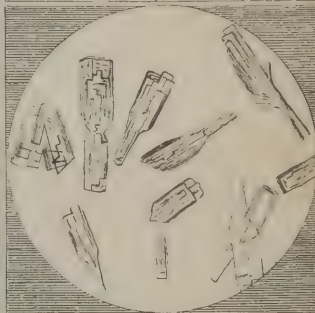


Fig. 5.

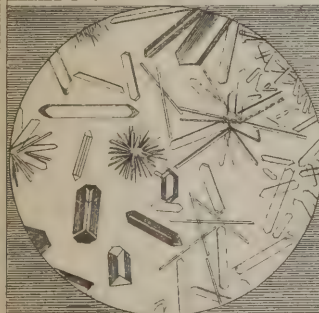


Fig. 6.

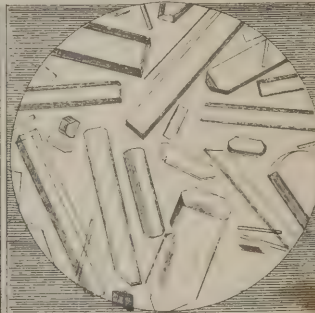




Fig. 7.

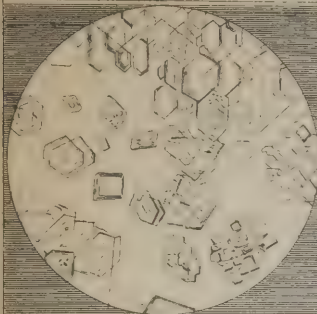


Fig. 8.

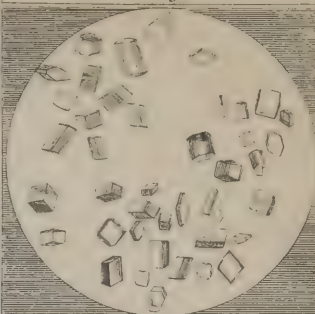


Fig. 9.

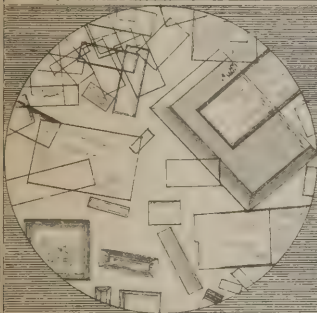


Fig. 10.



Fig. 11.

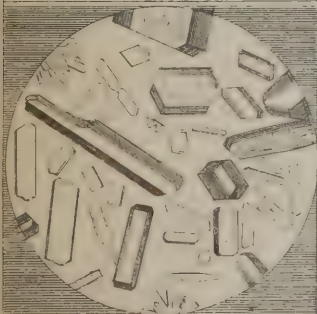


Fig. 12.





Fig. 13

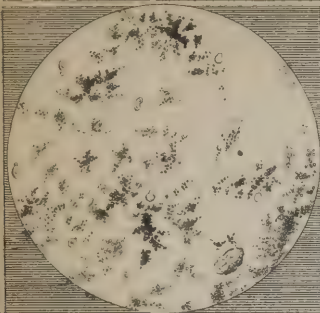


Fig. 14



Fig. 15



Fig. 16

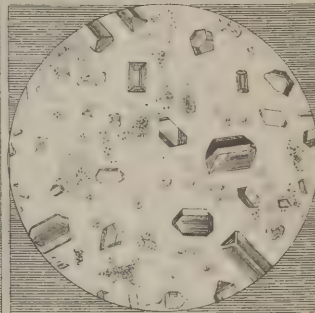


Fig. 17

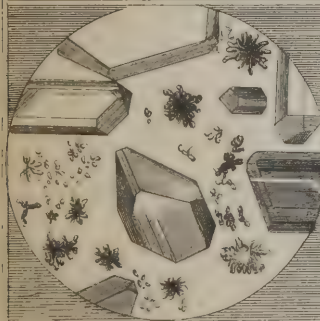


Fig. 18

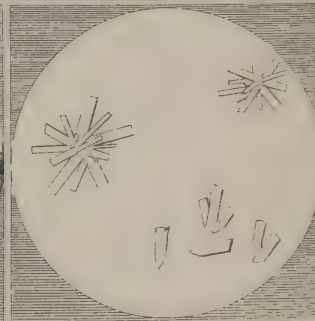


Fig. 19

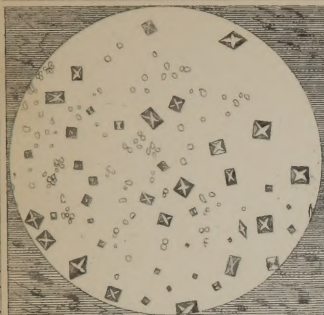


Fig. 20

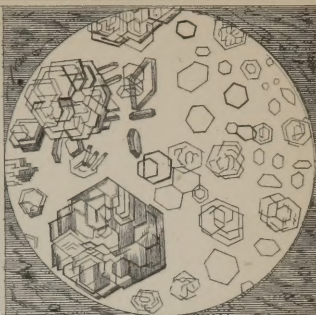


Fig. 21

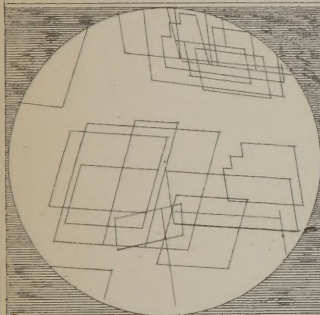


Fig. 22

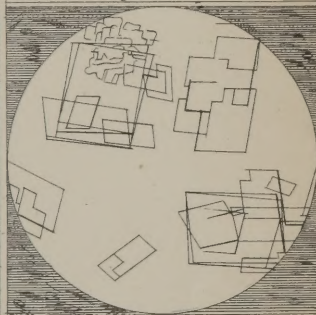


Fig. 23

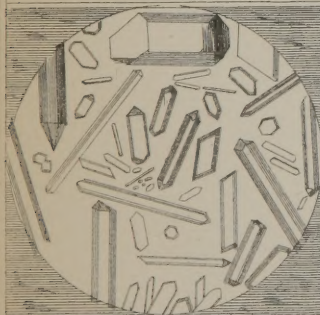
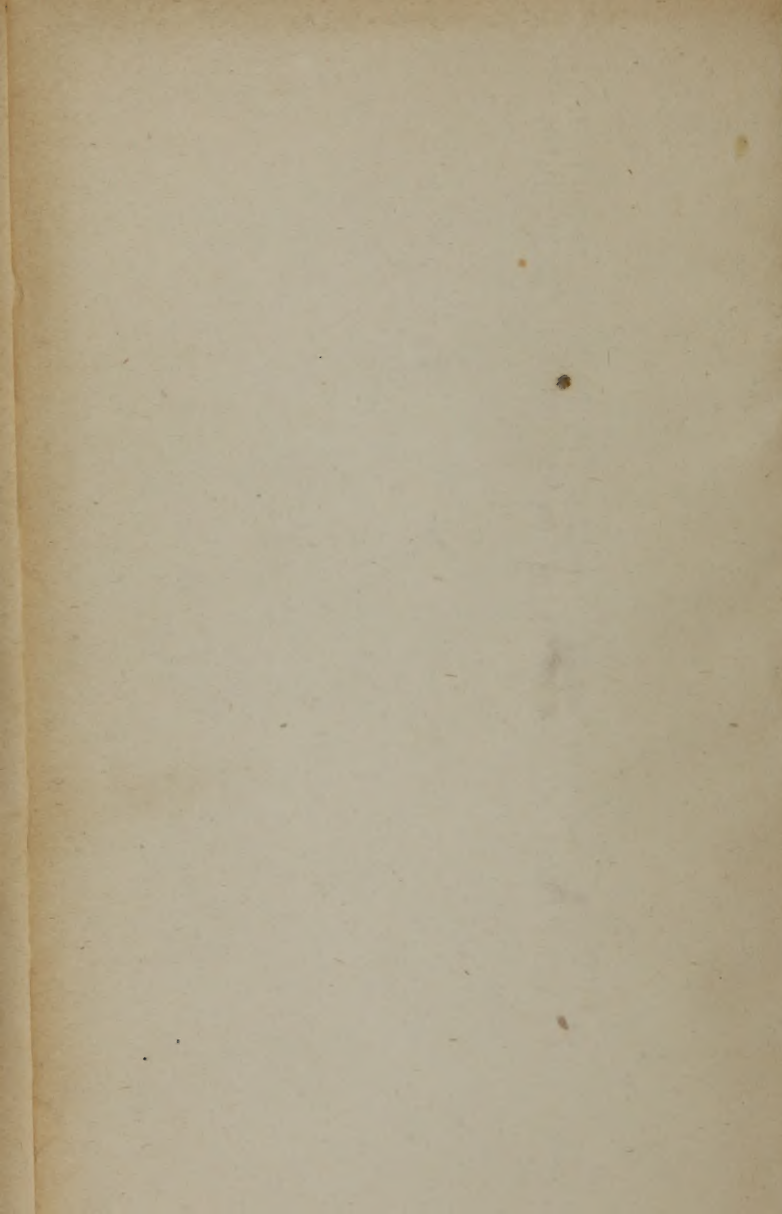


Fig. 24





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